The main building at Cambridge is of wood, more than fifty years old, and the whole, including the invaluable astronomical library, is in constant danger of destruction by fire. The estimated cost of new modern buildings is about 20,000*l.* A large telescope for work at present entirely neglected in the southern hemisphere could also be obtained for a further 20,000*l.*

A long list of the principal unpublished investigations is given, most of which are ready for completion if means be forthcoming. These will occupy about twenty-eight volumes of the *Annals*, *i.e.* almost two-thirds as many as have already been published during the half-century of the existence of the Observatory.

SCIENCE IN TECHNICAL AND PREPARATORY SCHOOLS.[1]

EDUCATION is probably more discussed at the present time than ever it was before. It has become a subject for the newspapers, and to some extent for the political platform. It would seem there is now really a hope that the ordinary man of affairs will soon appreciate its importance. The advocates of education in science and technology have for years appreciated the reality and understood the reason of successful foreign competition, and now the lesson is being impressively driven home to every manufacturer by the tale of diminishing exports. Facts such as these give the recent report, made for the Department of Special Inquiries of the Board of Education by Mr. James Baker, on technical and commercial education in East Prussia, Poland, Galicia, Silesia and Bohemia, a very high value. Written as it is from the point of view of a skilled observer generally interested in the development of British industry and commerce, the report will receive more careful attention from the practical men engaged in manufacture than would the opinion of a mere student of pedagogics.

With the exception, perhaps, of the part of Russia he visited, though even there some progress is being made, Mr. Baker tells of the rapid advances he found have taken place everywhere in the development of technical and commercial education. And, what is of particular importance to us in this country, he demonstrates that the efficiency of any nation's supply of technical instruction in its various grades depends directly upon the satisfactoriness or otherwise of the national supply of primary and secondary education. It is that student alone who has received a thorough and suitable grounding in preliminary subjects who benefits by the specialised instruction of the trade school and technical college.

But this cause by itself is not sufficient to explain the high standard of foreign systems of technical education. In Prussian Poland and in parts of Austria the want of continuity between the work of the day schools and the higher technical studies of the trade schools has been abolished by legislation. In this country attendance at school during the years of apprenticeship is optional with the result that even if the young workmen ever reach the classes specially designed to instruct in particular industries they have forgotten completely, by that time, their elementary knowledge; in the countries named, however, attendance at evening continuation or other schools is as compulsory as that at the ordinary day school. For instance, in describing the provisions for technical instruction at Posen, a town of 100,000 inhabitants in Prussian Poland, Mr. Baker writes of the Fortbildungsschules (continuation school, and the Gewerbschule or trade school: "This is for learners in all handicrafts. There is no payment, but the apprentices in all trades are compelled to attend this school under penalty of fine or even imprisonment. Lads commence here at fourteen and continue until eighteen, attending two afternoons a week and in the evenings. The employers are compelled to give their apprentices two afternoons a week, unless they are engaged upon work outside the town, when the lads are excused from attendance." Similarly, in connection with Trautenau, the Bohemian flax centre, with 16,000 inhabitants, we find: "Here all the apprentices must attend the trade continuation classes, which are held from six to eight in the evening and from eight to twelve a.m. on the Sunday. . . . In the Commercial Continuation School the same applies to business apprentices." And similar examples could be multiplied.

But it is impossible to manufacture, by any system of compulsion, enthusiastic students anxious to master everything known about the science of their trade and filled with a desire to improve upon the methods generally adopted. Continental authorities recognise this. It may be possible to raise the average ability of the workmen by enforced attendance at evening schools, but to discover the specially endowed craftsman who will repay all the trouble taken to place opportunities in his way, other plans are adopted. Here is one, expressed in Mr. Baker's words: "There is one great leverage the German schoolmaster possesses wherewith to lift his pupils into good work that an English teacher does not possess, and that is the fact, if a certain grade of work is passed, the student is freed from one or two years of military life, becomes a 'volunteer,' and only serves one year." But it is only in exceptional cases that this rule applies in Austrian towns, at all events in the lesser towns. Another means of attaining the same object is very common. In those schools which have not the right to exempt their pupils from one year of military service, an *Ausweis*, or leaving document, is employed, and on this is set forth the progress made, the behaviour and the diligence of the pupil, with a record of the attendance and a list of the subjects studied by the young man. This record has to be produced when the youth is called up for his time with the colours, and if the report is bad he may have to serve three years instead of two.

This subject of compulsory military service brings into high relief one great advantage the British workman has over his Continental contemporary in point of time. Mr. Baker writes eloquently in this connection: "In going through these technical schools I saw young men working at the most delicate handicrafts; they had just arrived at excellency; their skilled hands, guided by a highly cultured brain, were turning out work most delicately artistic; but they must lay down their tools and take up sword and rifle for two years, or three if in the cavalry or artillery; their hands must forego the exercise of their cunning, if they do not lose it altogether; . . . Herein is the Englishman's opportunity when he obtains the same advantages of education as the Austrian or German; he can at once leap ahead of his Continental competitor, for he gains these two years given up by the Continental to military service."

But perhaps the most remarkable characteristic of Austrian technical education is the extent to which decentralisation has been carried throughout the country. While making due provision for advanced work in a few large centres, the object of the authorities seems to be to bring suitable instruction in the technology of the particular industry of a district to the very doors of the workers. A notable instance of this, and it is typical, is the case of Turnau, or Turnov, the jewellers' town. It is a little place of 6500 inhabitants, whose chief industry is goldsmiths' work and the polishing and setting of jewels. Here has been established a Royal Imperial trade school for jewel cutting, polishing, engraving and setting in gold, but in addition to this technical institute there are four Volksschulen (primary schools), a Bürger school, and a continuation school in winter for handicraftsmen. The students of the Royal Imperial trade school come direct from the Volksschulen, beginning this special work at fourteen and remaining for four years. The tuition is free, but the lads receive no pay. The total number of pupils in the school is seventy-eight, and they are all being converted into cultured artisans. When they pass out of the school they are given a leaving certificate, which confers the full status of a workman and ensures treatment as an educated man for the holder.

The question naturally presents itself, What manner of men are in charge of institutions the object of which is to produce accomplished artisans who are also at the same time educated in a higher and more general sense? On this subject, too, the report under consideration supplies abundant information. In the description of the technical college at Prague a short life-sketch of Director Edward Cerny is given. He bears the title, by the way, of Royal and Imperial Councillor—a proof of the esteem in which men of science and educational leaders are held in Austria, where, as in Germany, such authorities are commonly nominated Privy Councillors, and receive titles and decorations. It is impossible in a short article to refer to all Director Cerny's qualifications; it must suffice to say that his case is quite general and that the common rule is to appoint

[1] Report on Technical and Commercial Education in East Prussia, Poland, Galicia, Silesia and Bohemia. By James Baker, 122 pp.
Board of Education Special Reports on Educational Subjects. Volume vi. Preparatory Schools for Boys: their Place in English Secondary Education. 531 pp.

"practical engineers or business men, thus bringing to bear on their teaching, not only the general education gained at school and their thorough knowledge of theoretical science, but also their practical experience of the workshop and business life."

These are but a few of the vital questions with which this valuable report is concerned. We heartily commend the volume to all who are interested in improving the home supply of technical education until it is not only on a level with that of Germany and Austria, but well in advance.

When we turn to the second of the reports, that concerned with the place in English secondary education of preparatory schools for boys, we are confronted with another stage in the preparation of the citizen for the duties of life. As every one knows, probably, the preparatory school undertakes the education, up to about fourteen, of the boy destined for our great public schools. Generally, after some five years at the public school, this fortunate son of well-to-do parents proceeds to either Oxford or Cambridge to continue his education. It is interesting to inquire as to the share science takes in the work of a preparatory school. It may be stated parenthetically that in a volume of 531 pp. only some sixteen pages are devoted to the teaching of mathematics and natural science together, though it is true nine of the sixteen are given to the latter.

It must be said at once that any science teaching at all in preparatory schools is the exception rather than the rule. To quote Mr. Archer Vassall, of Harrow, who deals with the subject in the official publication before us, "tentative efforts in scientific instruction have been made, and are still in progress at many of them"—and that is all that can be said. But there is nothing surprising about this. Since the sole function of the preparatory school is to prepare for the public school, those subjects only which are in demand in the second will be taught in the first, and, to quote Mr. Vassall again, "in public schools the teaching of science has only recently begun to take reasonable shape," a condition brought about by the regulations governing the award of University scholarships. So that to ensure an improved condition of things in the preparatory school men of science must bend their efforts towards securing reforms at Oxford and Cambridge.

Mr. Vassall's short article is chiefly concerned with a sketch of a suitable preparatory school course in natural science. In common with modern ideas he insists upon the need of individual practical work, and very properly urges that the study of science might well begin with what he calls "kindergarten physics." This mode of procedure has for some years been followed in higher grade boards schools, and in those other secondary schools which have adopted the syllabus of the Headmasters' Association. But we think Mr. Vassall is wrong in excluding chemistry from his preliminary course, for there are many excellent exercises which are in no way dangerous. Anyhow, a beginning has been made with science in preparatory schools, and if the masters will acquaint themselves with the results of experience in schools of other grades, we shall soon hear that science has gained for herself a more honourable place.

A. T. SIMMONS.

THE FIGURE OF THE EARTH.[1]

THE United States Coast and Geodetic Survey has just published a quarto volume containing an account of the transcontinental triangulations and measurements of an arc of the parallel in latitude 39°. It also has ready for publication the manuscript giving the result of an oblique arc in the eastern part of the United States. Both are contributions of great length and among the first of their kind in America.

Before entering upon the detail of the two arcs it may not be out of place to state that in order to obtain a measure of the dimensions of the earth, as represented by a spheroid, that is, by a surface generated by the rotation of an ellipse about its minor axis, it is essential that we should be in possession of at least two arcs or of an equivalent thereof. For combinations of two arcs of the meridian, their mean latitudes should differ widely; the same is true for the combination of two arcs of the parallel. We may also obtain an arc of the meridian with one of the parallel, but in every case the measures should be of considerable extent. Arcs of less than 5° (about 556 km., or 345 st. miles) would now be regarded as short ones. It has been stated that one of the arcs is an oblique arc, and as it possesses a great range of latitude and also of longitude and is supplied with a large number of astronomical measures, it is of itself sufficient for the deduction of values for the dimensions of the earth. Furthermore, it may be remarked that for any relatively small part of the earth's surface an osculating spheroid may be determined, as, for instance, was done for our oblique arc. Such a spheroid has the property that its surface is in best accord, as regards curvature, with the actual or physical one, the latter considered as a mathematical surface of equilibrium and generally known as geoid.

The definition of an osculating spheroid thus implies that the sum of the squares of the difference between the various astronomic and geodetic measures be a minimum. The mathematical treatment of the combination of the arc measures differs according to their nature, whether they are extended in a certain direction or whether large areas are covered, but in its generality it is necessarily laborious.

The salient points of the two arcs measured by the U. S. Coast and Geodetic Survey and the results reached may now be briefly stated. First, the arc of the parallel in latitude 39°.[1] It extends from Cape May, N.J., on the Atlantic coast, to Point Arena, Cal., on the Pacific coast, and ranges over 48° 46′ of longitude, with a linear development of about 4225 kilometres, or 2625 st. miles. The triangulation is supported by ten base lines with an aggregate length of 53½ st. miles, the longest or Yolo base being 10·9 miles in length, one half of these lines having a smaller probable error of measure than one part in a million. A characteristic of the triangulation is its rigidity imparted to it by quadrilaterals and other polygons. In crossing the Rocky Mountains, many of its sides exceed one hundred miles in length, and there is one side reaching to a length of 294 km., or 183 st. miles; the altitude of many of the stations is also considerable, reaching to 4300 metres, or 14 108 feet, in the case of Pike's Peak, and to 14,421 feet at Mount Elbert. All geometrical conditions subsisting in the triangulation are satisfied by adjustment, inclusive of the required accord of the base lines, so that the same length for any given line is found no matter from what line one may start. This involved much heavy work; for instance, the triangulation adjustment between the Salina and the El Paso base demanded the simultaneous solution of ninety-nine normal equations (with as many unknowns). In addition, the figures required the evolution of a correction to each of the two hundred and twenty-five observed directions.

Coming to the astronomical measures, we have distributed over or near the arc one hundred and nine latitude stations, occupied almost exclusively with zenith telescopes; there are, also, seventy-three azimuth stations, various methods having been used, and lastly we have twenty-nine telegraphically determined longitudes. These, of course, are of paramount importance for an arc of the parallel. There cannot be too many longitude stations in consequence of that great stumbling-block in geodesy, the local deflections of the vertical or plumb-line. These deflections of the zenith from a normal direction have been divided into two groups—those which are regional or manifest themselves with marked common features over thousands of square miles, and those which are quite local and greatly depend upon the surface features immediately surrounding them.

These deflections, even in level countries, average about 2·5″; but in mountainous regions this deflection is greatly surpassed. Thus we find for deviation of the plumb-line at Patmos Head station 12″ to the north, at Colorado Springs 25″ to the west, at Salt Lake City about 17″, and at Ogden about 15″ to the east, at Genoa Station, Nev., nearly 29″ to the west, the quantities depending to some extent on the spheroid of reference; but their amount and direction are obviously well accounted for by the position of known attracting masses. In connection with this, continental attraction may manifest itself and be recognised by the astronomical amplitude of the longitudes of extreme stations of a long arc being in excess of the corresponding geodetic amplitude. The matter cannot be further pursued here in detail, but it may suffice to state that the average curvature of the equipotential surface of the geoid along the parallel of 39°

[1] Abridged from a paper on recent contributions by the United States Coast and Geodetic Survey to our knowledge of the earth's shape and size, by Mr. C. A. Schott, in the *National Geographic Magazine*, New York.

[1] U. S. Coast and Geodetic Survey; H. S. Pritchett, Superintendent. The Transcontinental Triangulation and the American Arc of the Parallel. By C. A. Schott, Assistant, Coast and Geodetic Survey, Washington, D.C., 1900.